JANUARY–MARCH 2004 VOLUME XXXVI, NUMBER 1

TSUNAMI NEWSLETTER

International Tsunami Information Center

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Caribbean Tsunami Workshop participants (see story page 7-8). In front, from left to right: Carlos Mendoza (Consultant), Victor Huerfano (PRSN), Juan C. Moya (Southwest Texas State Univ.), Aurelio Mercado (Univ. of Puerto Rico), Julio Oms (USGS-Puerto Rico), Hermann Fritz (Georgia Inst. of Technology), Laura Kong (ITIC). Standing, from left to right: Sonny Beuachamp (PRSEMA), Narcisse Zahibo (Univ. of Antilles Guyane, Guadeloupe), Philip Liu (Cornell), Kurt Grove (Sea Grant, Univ. of Puerto Rico), Cherri Pancake (Oregon State Univ.), Dieter Kelletat (Univ. Duisburg-Essen, Germany), Harry Yeh (Oregon State Univ.), Rachel Gross (Natl Weather Svc.-San Juan), George Pararas-Carayannis (Hawaii), Ahmet Yalciner (Middle East Technical Univ., Turkey), Chip McCreery (PTWC), José Borrero (Univ. of Southern California), William McCann (Earth Scientific Consultants), Costas Synolakis (Univ. of Southern California), Patrick Lynett (Texas A&M Univ.), Marie Gonzalez (FEMA-Caribbean), Jose Bravo (FEMA-Caribbean), Roy Watlington (Univ. of the Virgin Islands), Emile Okal (Northwestern Univ.), Alejandro de la Campa (FEMA-Caribbean), George Maul (Florida Inst. of Technology), Jose Lebron (OMEP), Galen Gisler (Los Alamos Nat'l Lab, USA), Walter Snell (NWS-San Juan), Carol Prentice (USGS), Christa von Hillebrandt (PRSN), Hiraldur Sigurdsson (Univ. of Rhode Island), Judy Zachariasen (USGS), Jesus Frau (FEMA-Caribbean), Uri ten Brink (USGS-Woods Hole), Martitia Tuttle (M. Tuttle & Associates).

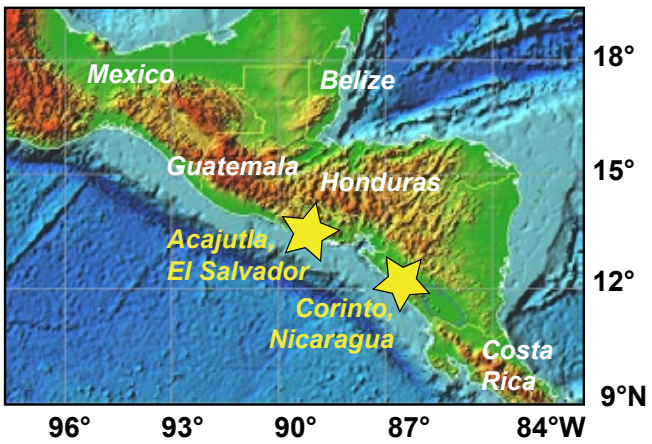
SUMMARY OF EARTHQUAKES IN THE PACIFIC
Occuring January-March 2004

With surface wave or moment magnitude (M_w) greater than or equal to 6.5 and a depth no greater than 100 km, or an event for which a Tsunami Information Bulletin (TIB) or Regional Watch Warning (RWW) was issued. Epicenter, M_S, and M_W from USGS National Earthquake Information Center (NEIC, G); M_W and centroid depth from Harvard (H); M_W from PTWC (P) at action time.

DATE	TIME (UTC)	LOCATION	LATITUDE	LONGITUDE	DEPTH (km)	M_W	M_S	PTWC ACTION	ACTION TIME (UTC)	Tsuami ? Damaging ?
Jan 3	16:23	SE of Loyalty Islands Region	22.231 S	169.636 E	16	7.1 (H) 7.0 (P) 6.8 (G)	7.1	TIB	16:41	No No
Jan 25	11:43	Tonga Islands	16.840 S	174.168 W	145	6.7 (G,H,P)	N/A	TIB	12:01	No No
Jan 28	22:16	Seram Indonesia	3.131 S	127.420 E	20	6.7 (G) 6.6 (H,P)	6.5	TIB	22:35	No No
Feb 5	21:05	Irian Jaya Region, Indonesia	3.579 S	135.489 E	19	7.0 (H) 6.9 (P) 6.8 (G)	7.1	TIB	21:22	No No
Feb 7	2:43	Irian Jaya Region, Indonesia	3.942 S	134.987 E	15	7.3 (G,H) 7.4 (P)	7.5	TIB	02:59	No No
Feb 8	8:59	Irian Jaya Region, Indonesia	3.679 S	135.316 E	15	6.5 (G) 6.7 (H,P)	6.9	TIB	09:15	No No

NEW SEA LEVEL STATIONS INSTALLED IN CENTRAL AMERICA

Real-time sea level data are now being received by the PTWC from two stations in Central America. In January, 2004, PTWC Senior Electronics Technician Richard Nygard installed new tsunami tide gauge stations in Corinto, Nicaragua and Acajutla, El Salvador, in cooperation with the Instituto Nicaragüense de Estudios Territoriales (INETER) and the Servicio Nacional de Estudios Territoriales (SNET). Each country provided exceptional logistical support for equipment shipping, site preparation, and local transportation. The new data streams resulted from discussions on Central America–Pacific Coast Regional Tsunami Warning



PTWC Senior Electronics Technician Rich Nygard (left) met with INETER Director Claudio Gutierrez Heute (right) to discuss the Corinto installation and future sea level requirements for the planned Regional Tsunami Warning System.

At the Corinto tide station (Nicaragua), the GOES antenna and solar panel were mounted atop building adjacent to the pier. Nygard (right) was assisted by INETER staff Antonio Lopez, Sergio Cordonero, and Martha Herrera.

NEW SEA LEVEL STATIONS, *continued*

System data needs, initiated by the ITIC Director at the ISDR Regional Consultation on Early Warning in Guatemala, June, 2003, and followed up on at the ITSU-XIXth Session in September. Funding for the station installations was shared by the UNESCO/ IOC Tsunami Programme, and the US National Weather Service's Pacific Region.

The systems consist of a Druck PTX-1830 pressure sensor deployed with a stilling well, Vaisala 555 Data Collection Platform, electronics, GPS clock, and 12-volt battery housed in a 24"x20"x10" Hoffman weather-tight box, one 20-watt solar panel to provide power, and a yagi antenna for satellite data transmission. Sea level data are collected at 2-minute intervals, and transmitted hourly from the tide station through the GOES satellite to the ground station at Wallops Islands, Virginia, USA, and then to the PTWC.

In El Salvador, Nygard (middle) was assisted by SNET staff. Carlos Pullinger (Director Servicio Geologico, right), and Edwin Escobar (Coordinador Unidad de Ingeniería y Mantenimiento,left) provided excellent coordination support prior to arrival to ensure that the proper equipment was received in good condition.

During December, 2003, Senior PTWC Electronics Technician Rich Nygard visited Midway Island to perform station maintenance on the PTWC tide station. He also assisted Ken Kuhs of the U.S. National Ocean Service (NOS) with the maintenance of the existing NOS tide station and with preparations for the proposed real time sea level data transmission link, and assisted Don Anderson of the U.S. Geological Survey's Albuquerque Seismological Laboratory with the removal of the existing Geotech borehole seismometer and installation of a new STS-2 broadband seismometer on the island.

Communications tower at Acajutla station. (El Salvador) In the field, Nygard (right) and Escobar were joined by Saul Canjura (left).for the installation of the new systems.

RICHARD H. HAGEMEYER PACIFIC TSUNAMI WARNING CENTER : SEISMIC DATA AND ANALYSIS CAPABILITIES FOR PACIFIC RIM EVENTS

Charles (Chip) McCreery, Geophysicist-in-Charge, Richard H. Hagemeyer Pacific Tsunami Warning Center, 91-270 Ft. Weaver Rd., Ewa Beach, HI 96706 USA, Charles.McCreery@noaa.gov

The U.S. operates two tsunami warning centers: the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) located in Ewa Beach, Hawaii, and the West Coast/Alaska Tsunami Warning Center (WC/ATWC) located in Palmer, Alaska. WC/ATWC is responsible for local, regional, and distant tsunami warnings issued to Alaska, British Colombia, Washington, Oregon, and California. PTWC is responsible for local, regional, and distant tsunami warnings issued to Hawaii. As the U.S. National Center, it is also responsible for regional and distant tsunami warnings issued to American Samoa, Guam, and all other U.S. possessions and interests in the Pacific. In addition, PTWC is the operational center for the Tsunami Warning System in the Pacific organized by the Intergovernmental Oceanographic Commission of UNESCO. As such, PTWC issues warnings for regional and distant tsunamis to almost every country around the Pacific Rim and to most Pacific Island states.

In general, procedures used by PTWC to provide tsunami warnings are the following: Hardware and computer programs continually monitor seismic waveform data streams and alert watchstanders whenever large and widespread signals are detected from a significant earthquake. Watchstanders then rapidly locate the earthquake hypocenter and determine its magnitude using a combination of automatic and interactive procedures. If the earthquake is shallow and is located under or very close to the sea, and if its magnitude exceeds a predetermined threshold, a warning is issued based on there being the potential that a destructive tsunami was generated. As sea level data are received from the nearest gauges, the tsunami is confirmed, if it exists, and measured. These measurements are then evaluated in the context of historical events from the region, applicable numerical simulations,

PTWC CAPABILITIES, *continued*

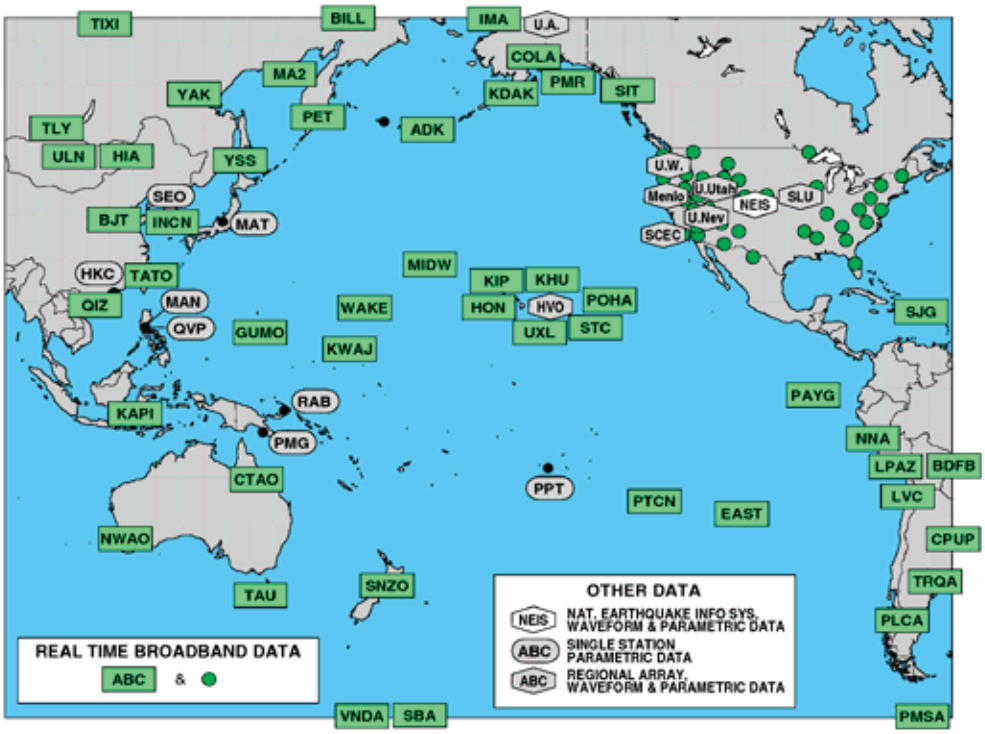


Figure 1. Seismic stations and networks spanning the Pacific providing waveform and parametric data to PTWC.

and other predictive tools based on the earthquake and sea level parameters. Based on this evaluation the warning is continued, upgraded to cover a larger area, or cancelled. These procedures apply to the case of both a destructive regional or teletsunami in the Pacific Basin, and a local or regional tsunami in Hawaii.

Over the past several years, and as a result of efforts by many partner organizations as well as PTWC, significant improvements have been realized in PTWC's operational capabilities. The amount and quality of seismic data has greatly increased. The methodologies used for rapid earthquake analysis have improved and become more streamlined. The array of coastal gauges used to evaluate a tsunami, as it is underway, has better spatial coverage and has been significantly enhanced by six strategically-placed deep ocean tsunameters. Lastly, operational forecasting, based on precomputed numerical models and constrained in real time by the seismic and sea level data, is beginning to be implemented and has demonstrated its utility in a recent event in 2003.

This is the first in a series of reports on PTWC operations. It focuses on recent improvements to PTWC's seismic capabilities for Pacific Rim earthquakes capable of generating regional or Pacific-wide destructive tsunamis. Since PTWC's initial warnings, watches, and other bulletins are based entirely on preliminary seismic parameters, the seismic data and data processing capabilities are critically important to tsunami warning operations.

As recently as 1996, PTWC relied on only a very limited set of seismic data to locate and determine the magnitude of distant earthquakes. Outside of Hawaii, the only continuous, real-time waveform data received were from eight short-period and six low-gain, long-period vertical seismometers located in Alaska and the continental U.S. These data were transmitted from the U.S. Geological Survey's (USGS) National Earthquake Information Center (NEIC) in Colorado to PTWC by modem over a dedicated circuit. The dynamic range of the data was very limited because the system was based on a 12-bit digitizer. In addition, the data were contaminated with frequent spikes from the 20-year-old hardware, so modern processing, such as filtering or automatic arrival picking, was not feasible. The data could, however, be used for event detection, manual arrival picking, and manual amplitude scaling for magnitude. Supplementing these data were time series data from Hawaii seismic stations, automatic first arrival picks from NEIC, and first arrival times transmitted to PTWC from a few cooperating international observatories. These data were usually adequate for computing shallow epicenters to within a degree, but typically provided little depth control since the closest stations were often too far away

PTWC CAPABILITIES, *continued*

to provide much constraint and depth phases were difficult to recognize on the narrow-band records. Lastly, computation of the surface wave magnitude, on which the warning criterion was based, was very slow for earthquakes in the southern or western Pacific due to the long delay as surface waves propagated to the U.S.

Beginning in about 1997, PTWC began importing data over the Internet from a growing number of international broadband seismic stations having data available in near real-time from data servers of the International Deployment of Accelerometers Project (IDA) and the USGS Albuquerque Seismological Laboratory (ASL). These data were generally of very high quality and gave PTWC new opportunities to improve its performance by utilizing their wider spatial coverage and by being able to apply more modern seismic analysis techniques to the tsunami warning problem.

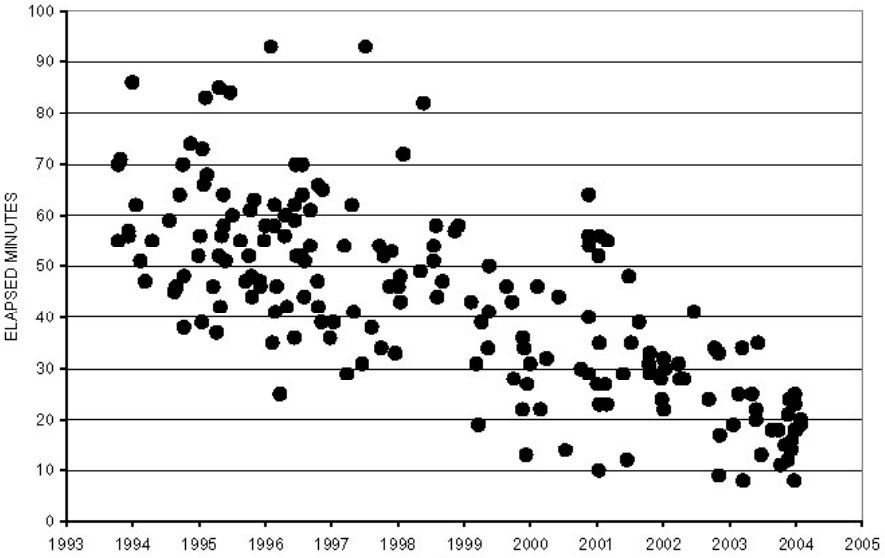


Figure 2. The number of minutes elapsed between the occurrence of a large Pacific earthquake and the initial PTWC bulletin, plotted by year. The steadily decreasing values are due to many factors, including more and better quality data, and more automated and efficient data processing.

Then in late 1999, the CREST program (Oppenheimer et al., 2001), part of the U.S. National Tsunami Hazard Mitigation Program (NTHMP), provided PTWC with hardware, software, communication circuits, and technical support for the USGS "Earthworm" seismic data exchange and processing system (Johnson et al., 1995) to serve as a back end to PTWC's existing data processing environment. It allowed PTWC to receive continuous digital broadband seismic data from the U.S. National Seismic Network, from U.S. regional seismic networks that also operate "Earthworm" systems, and via NEIC from other worldwide networks such as the IRIS Global Seismic Network and AFTAC Global Telemetered Seismic Network. It also allowed PTWC and WC/ATWC to more easily exchange their seismic and some of their sea level data continuously and in real time. In total, PTWC now receives data from about 90 broadband vertical seismic sensors located around the Pacific, including stations in S. America, Antarctica, New Zealand, Australia, SE Asia, Japan, Russia, and some Pacific islands, as well as in Alaska and the continental United States (Fig. 1). These data are typically digitized at 20 samples per second with a 24-bit digitizer. These are the highest quality seismic data available with a wide dynamic range to stay on scale for all but the largest nearby earthquakes, and with a frequency response that permits accurate timing of high-frequency *P*-wave arrivals at a few cycles-per-second and magnitude measurements at up to several hundred seconds period for the largest earthquakes. For reliability, PTWC operates two independent "Earthworm" systems and uses both the dedicated CREST circuit and the public Internet to receive data. For additional reliability, PTWC continues to import data, about 40 broadband signals, directly over the Internet from the IDA hub and from ASL that are outside the CREST network. While these data and systems are not flawless – there are sometimes extended station outages, data streams have intermittent gaps and overlaps, and whole systems and communication links occasionally fail – there is enough redundancy so sufficient data to accomplish PTWC's mission should be available except for the most catastrophic circumstances. In such situations, PTWC and WC/ATWC can serve as a backup centers for each other and the CREST capabilities help facilitate this.

The new high-quality seismic data provide the foundation for improved warning center performance. Their extensive geographical distribution permits earlier detection of an earthquake's occurrence and more rapid and accurate hypocenter calculations. The broader frequency band of the data and larger number of traces permit recognition of depth phases for more accurate depth determinations. In addition, much lower-frequency seismic waveforms allow techniques for determining moment magnitude, a more accurate measure of size than the surface

PTWC CAPABILITIES, *continued*

wave magnitude for the largest earthquakes with the most tsunamigenic potential. PTWC now routinely calculates M_{wp}, the moment magnitude based on the first-arriving *P*-waves (Tsuboi, et al., 1995), and M_m, mantle magnitude, from surface waves that can be directly converted to moment magnitude (Okal and Talandier, 1989). These computations are done for each of the available broadband seismic signals and final values are typically based on 30-50 independent measurements. As a result of having these capabilities, M_W was adopted in June 2003 as the magnitude used in tsunami bulletins and for warning criteria. The new data also make possible automatic teleseismic epicenter determinations. PTWC has now implemented the teleseismic *P*-wave picker and associator developed by WC/ATWC and the two centers exchange their automatic hypocenters as they are produced in the minutes following an earthquake. The broadband data also facilitate techniques for the discrimination of so-called "tsunami" or "slow" earthquakes that carry an especially high tsunamigenic potential (Kanamori, 1972). These events are usually recognized by unusually high ratios between low and high frequency seismic energy, and PTWC now routinely computes M_W-M_S and Theta values (Newman and Okal, 1998) as discriminants to check for this possibility. Additional analysis techniques including computation of the centroid moment tensor, slip distributions, and fault rupture dynamics are possible with current data streams and likely to be implemented over the next few years. This type of source information would be useful not only for estimating tsunamigenic potential, but also to help set initial conditions of numerical models used for tsunami wave forecasting.

An important measure of how these seismic enhancements have helped to improve PTWC's performance is the elapsed time from the earthquake's origin time to a PTWC bulletin issuance (Fig. 2). From 1994 through 1998, it took 30-90 minutes to issue a bulletin. After 1999, when Earthworm and CREST circuits were installed, it took only 20-60 minutes. And, since June of 2003, when procedures were officially changed to use M_W instead of M_S for magnitude criteria, it has taken 25 minutes or less. This improved response time translates into the issuance of warnings more quickly to areas at risk closer to the source where they are needed most.

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Tsunami warning operations area at the Richard H. Hagemeyer . Pacific Tsunami Warning Center, where Geophysicist Barry Hirshorn (left) and Geophysicist-in-charge, Chip McCreery, monitor incoming seismic data. Located in Ewa Beach, on the Island of Oahu, PTWC is one of two tsunami warning systems operated by the US National Weather Service. Co-located with the tsunami center are various weather data receivers and the USGS Honolulu Magnetic Observatory.

CARIBBEAN TSUNAMI WORKSHOP, 30-31 MARCH 2004

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The Caribbean Tsunami Workshop was held at the San Juan Beach Hotel, San Juan, Puerto Rico, on March 30-31, 2004, under the sponsorship of the Geo-Hazard Mitigation Program at National Science Foundation, the Puerto Rico State Emergency Management Agency, and the University of Puerto Rico's Department of Marine Sciences and Sea Grant Program, The workshop had 65 participants, including 25 invited speakers who are researchers in tsunamis, paleotsunamis, seismology, geology, oceanography, coastal and electrical/computer engineering, meteorologists, and personnel from state and federal emergency management agencies (see group photo on cover).

The tsunami threat in the Caribbean is dominated by events occurring along the margins of the Caribbean plate. Seismic faults, high bottom slopes, and near shore active volcanoes (including Kick'em Jenny—the most active volcano in the Lesser Antilles Arc), combine to present high tsunami risk from multiple sources in a relatively compact area. The first series of presentations in the workshop focused on documenting these multiple threats and risks, ones that are ever increasing due to the large, and increasing, coastal population density in the region. The evidence for flank collapse for the western-facing slope of Kick'em Jenny was presented, and numerous scarps (both large – 50 to 20 km wide – and small) were identified along the slopes of the Puerto Rico Trench. At the head of these scaps, several hundreds of meters-wide cracks are also evident, suggesting an ongoing slumping process. It could be concluded from these presentations that tsunami threat in the Caribbean caused by a slope failure could be as high as those due to earthquakes.

The next series of speakers addressed the question of whether the use of only the local historial tsunamis (only one teletsunami has been recorded since 1498), to evaluate Caribbean tsunami risk, presented a realistic scenario. Paleotsunami evidence from several Caribbean islands was presented, hinting not only that the risk is under-estimated, but also that the occurrence of large, catastrophic, events—some possibly propagating into the region from the Atlantic Ocean—seems to be more common than once thought.

This was followed by presentations describing recent national and international tsunami-related programs. Several tasks of the ongoing Puerto Rico Tsunami Warning and Mitigation Program were summarized, including the initial steps in the tsunami warning system for Puerto Rico and the US Virgin Islands. Simulation results of the 1867 US Virgin Islands tsunami, and a presentation on the potential devastation to the economy of the islands should a similar-sized tsunami occur today. Next, the recently created Network for Earthquake Engineering Simulation (NEES) Program was described, emphasizing the tsunami wave basin located at Oregon State University. An explanation of the multidisciplinary usefulness of integrated tsunami scenario simulations was also presented; the global approach integrates the expertise of specialists from different disciplines to deal with the tsunami hazard from near its source and all the way to down to its effect on communities and the environment. This section on national and international programs finalized with presentations on the potential role of the UNESCO/IOC International Tsunami Information Center and the Pacific Tsunami Warning Center (PTWC) in addressing the tsunami hazard in the Caribbean region. As an example, for the M 6.5 September 22, 2003, Puerto Plata, Dominican Republic earthquake, the PTWC alerted the Puerto Rico Seismic Network of the potential tsunamigenic event within minutes .

Dr. Ahmet Yalciner presented a summary of tsunamis that have impacted Turkey.

The rest of the workshop was dedicated to presentations on basic research. A presentation introduced practical ways to discriminate between earthquake and landslide tsunamis, both in the far and near field. Results on both physical

CARIBBEAN WORKSHOP, *continued*

and computer modeling of landslide generated tsunamis followed, including three-dimensional effects. Preliminary results of the very practical issue of tsunami forces on the runup zone were also addressed. A comparison of the tsunamigenic similarities and differences between the Mediterranean and Caribbean Seas was made.

Being a great concern to many islands and nations in the eastern Caribbean Sea region, the issue of a potentially large explosion as the Kick'em Jenny submarine volcano must be addressed. A two-dimensional numerical simulation of such a scenario was carried out using an adaptive mesh Eulerian multi-fluid compressible hydrocode, with realistic equations of state for air, water, and basalt. It was shown that even for extremely catastrophic explosive eruptions, tsunamis from the volcano are unlikely to pose significant danger to nearby islands. This is basically because explosive eruptions do not couple well to water waves; and the waves are highly turbulent and dissipative.

Finally, as a result of a brainstorming session, the following recommendations were suggested as a guide to further tsunami-related research in the Caribbean Sea region:

1. *Continue with the paleotsunami field studies, since this helps in quantifying the risk. This should include absolute datings. In addition, for the purpose of giving more credibility to the claim that large, multi-ton, boulders found inshore are due to large tsunamis, studies should be conducted to determine the distribution of finer tsunami deposits and its potential correlation with the distribution of the boulders. And, studies should be conducted on potential teletsunami or landslide sources that could account for the geometry, orientation and distribution of such "paleotsunami" deposits.*
2. *Continue with research on the problem of discriminating between hurricane and tsunami deposits. This should include the issue of the physics of how rocks and boulders are picked up and carried inland.*
3. *Initiate studies on the potential effects of a large tsunami on the economy and infrastructure of the densely populated island/nations in the Caribbean, including vulnerability studies and potentially damaging effects on the large number of cruise ships that are normally docked at any given moment in the islands.*
4. Initiate *studies on the geology of the seafloor in tsunami-prone (from earthquakes and landslides) areas, including correlation of slumps with bottom material. It should also include investigations of the above-water geology in landslide-prone areas.*
5. *Initiate monitoring of active volcano slopes with the purpose of documenting the interaction of debris and pyroclastic flows with the ocean*.
6. *Promote the need for real-time sea level monitoring in the region.*
7. *Promote the participation of Puerto Rico and the U.S. Virgin Islands in the USA National Tsunami Hazard Mitigation Program.*
8. *Identify sources of near shore bathymetric and topographic data in the region, and promote its collection in a centralized data base*.
9. *Export to the rest of the Caribbean the technology needed for tsunami flood mapping, and educational outreach.*

At the end of the workshop, and as a result of its success, it was unanimously decided to publishpeer-reviewed proceedings. Please visit the workshop web site at *http://nsfctw.uprm.edu* for the workshop agenda and abstracts.

Tsunami Hazard Zone signs similar to those used in the USA have been posted in many coastal communities throughout Puerto Rico.

PUERTO RICO TSUNAMI TECHNICAL REVIEW COMMITTEE ESTABLISHED

Christa G. von Hillebrandt-Andrade, Director, Puerto Rico Seismic Network (PRSN), University of Puerto Rico at Mayagüez; Principal Investigator for Puerto Rico Tsunami Warning and Mitigation Program, christa@midas.uprm.edu

On April 1, 2004 the Puerto Rico Tsunami Technical Review Committee (PR-TTRC) met for the first time at the headquarters of the Puerto Rico State Emergency Management Agency (PRSEMA). Twenty five representatives from state and federal agencies and the University of Puerto Rico attended the meeting.

The two invited speakers were Dr. Laura Kong, Director of the International Tsunami Information Center and Dr. Charles McCreery, Geophysicist–in– Charge of the Richard H. Hagemeyer Pacific Tsunami Warning Center. They gave an overview of tsunamis, the Pacific Tsunami Warning System and the role of the Hawaii Tsunami Technical Review Committee (HI-TTRC).

The establishment of this committee was one of the action items agreed upon at the Caribbean Tsunami Protocol Workshop, which was held in Mayagüez, Puerto Rico in January, 2003. Similar to the HI-TTRC, the activities of the PR-TTRC will focus:

1. Identification of the tsunami hazard and risk
2. Tsunami warning protocols
3. Emergency management and mitigation activities
4. Public awareness

Specific issues that were discussed included the feasibility of installing existing or new tide gauges in Puerto Rico and the U.S. Virgin Islands, greater accessibility of the PR Tsunami Video (translation into English, close captioning, DVD, Sign Language), alarm systems, the existing tsunami warning protocol and establishment of an email list server for the PR-TTRC.

PRSEMA Hazards Mitigation Director Sonny Beauchamp (standing) and PRSN Director Christa von Hillebrandt (seated to his right) described the goals of the newly-formed PR-TTRC, which is modelled after the successful Hawaii TTRC.

The next meeting will be held in September, 2004, and efforts will be made for the participation of representatives from the Departments of Education and Tourism; Ports and Highway Authorities, Police, Civil Air Patrol and the U.S. Virgin Islands. At present, the PR-TTRC is coordinated by the University of Puerto Rico at Mayagüez as part of the Puerto Rico Tsunami Warning and Mitigation Program. This program was established in the year 2000 with funding from U.S. Federal Emergency Management Agency (FEMA) and, as of 2004, is now supported by the PRSEMA.

In addition to implementing a Tsunami Warning System for Puerto Rico and the U.S. Virgin Islands in coordination with PRSEMA and the National Weather Service San Juan Weather Forecast Office, Professor Aurelio Mercado (left) and PRSN Director Christa van Hillebrandt (right) are also active in the community. As part of the 100th anniversary celebration of the University of Puerto Rico, Mercado and von Hillebrandt made earthquake and tsunami awareness presentations at the local shopping mall.

ITSU NATIONAL CONTACTS UPDATE

Since the last issue of the Tsunami Newsletter the post of National Contact has changed in three countries; Chile and Indonesia and Japan. Please update your records accordingly:

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Located in Honolulu, the International Tsunami Information Center (ITIC) was established on November 12, 1965, by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In 1968, the IOC formed the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU).

The present 26 Member States are: Australia, Canada, Chile, China, Colombia, the Cook Islands, Costa Rica, the Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Mexico, New Zealand, Nicaragua, Peru, Philippines, the Republic of Korea, Samoa, Singapore, Thailand, the Russian Federation, and the United States of America.

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